TRANSTHORACIC RESECTION OF THE LOWER END OF THE ŒSOPHAGUS IN A DOG.[1]

UNDER NEGATIVE AIR-PRESSURE IN SAUERBRUCH'S BOX; A PERSONAL EXPERIENCE.

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LAST summer, when visiting the University of Breslau, on a flying trip to a number of German universities, I had the pleasure of witnessing a resection of the œsophagus just above the cardia, done by Dr. Sauerbruch, one of the assistants of Professor von Mikulicz, in the well-known box constructed by him.

I had read with intense interest, in the early part of the year, the publications by the Breslau Clinic regarding intrathoracic operations under negative air-pressure, as well as those emanating from Heidelberg, favoring the performance of such operations under increased air-pressure, without the aid of the pneumatic box, or cabinet, which to-day, in the scientific world, bears the name of its author, F. Sauerbruch.

I crossed the ocean with the intention of making a thorough study of Sauerbruch's method at the place of its conception, and the pleasure that I derived therefrom is mingled with but one regret, namely, that the time at my disposal was so extremely limited.

Before describing the particular operation, which forms the title of this paper, I should like to make a few general remarks regarding the origin and plan of the method.

In an original communication published by Dr. Sauerbruch in No. 6 of the *Centralbl. für Chirurgie*, 1904, February 13, entitled, "On the Ways and Means of excluding the Injurious Effect of Pneumothorax in Intrathoracic Operations,"

[1] Read before the New York Surgical Society, December 14, 1904.

he stated that in October, 1903, he had been charged by his chief, Professor von Mikulicz, to investigate the question as to how best to prevent the occurrence of a pneumothorax in intrathoracic surgery, the main point to be considered being to render practicable transpleural resections of the œsophagus for carcinoma, a procedure which, so far, had been followed by the most disastrous results in experiments upon animals as well as in the human subject.

The inevitable occurrence of pneumothorax upon opening the thoracic cavity being the chief obstacle to our working within the same with equal freedom as we do within the abdominal cavity, the direction in which the theoretical solution of the problem lay, was clear. It was evident that such operations would have to be done either by increasing the pressure within the lungs, exposing at the same time the thoracic cavity to ordinary atmospheric pressure, or by reversing conditions, that is to say, placing the thoracic cavity under decreased or negative pressure, while the bronchial system remains exposed to normal atmospheric pressure. Whether or not this could be practically carried out, of course, could be determined by experimental research only.

The method, long employed by physiologists, of rhythmically pumping air into the lungs through a tube tied into the trachea, the only method of operating under increased pressure known up to that time, had been tried by von Mikulicz, but his experiments upon animals had not been satisfactory. He therefore resolved to try the other alternative, the ways and means of which he left to Sauerbruch to discover. Von Mikulicz's charge to Sauerbruch, therefore, was to try and find a way by which it would be possible to open the thorax with the atmospheric pressure reduced, yet enabling the surgeon to do his work.

With this object in view, Sauerbruch set to work.

He first constructed a rather primitive apparatus, consisting of a glass cylinder closed at either end by means of guttapercha paper; the latter contained three openings (one larger and two smaller ones) on one side and a larger hole on the

other (Fig. 1).* Through the two larger opposite holes the animal was pulled so that the head rested outside of the cylinder at one end, the hind legs and abdomen at the other, the trunk remaining within the cylinder. The necessary instruments having been placed within, Sauerbruch pushed his hands through the two smaller openings at the head end. After this all holes were closed air-tight, and air was withdrawn from

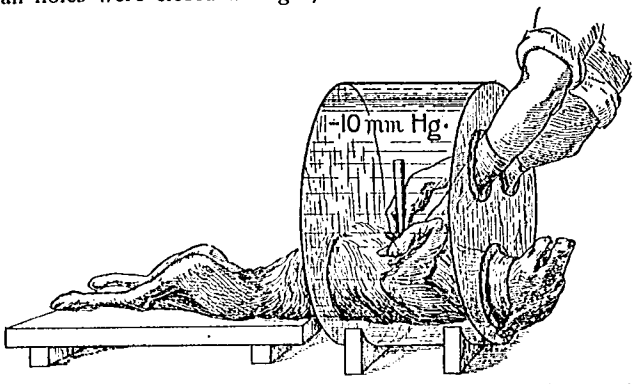

FIG. 1.—Sauerbruch's original primitive apparatus, which was constructed for the sake of finding out whether the thoracic cavity of a dog could be opened bilaterally with impunity by atmospheric air-pressure being reduced.

within (by suction) through a drainage-tube, until the pressure was reduced to the desired degree. Then the thorax of the animal was opened bilaterally. The lungs did not collapse and respiration continued undisturbed. Three minutes later a rent in one of the membranous end coverings of the cylinder occurred, with the result that the lungs collapsed under the atmospheric pressure and the animal died almost instantly.

Encouraged by this experiment, Sauerbruch had another improved box constructed (Fig. 2). This was about five feet long, a little over three feet wide, and about four feet high. It was made of wood three-fourths of an inch thick, tin-lined, and covered with a glass roof. The door was not quite four feet high and two feet wide, and was hermetically closed by

* The figures have been copied from Sauerbruch's and Brauer's articles repeatedly referred to.

means of rubber straps. In the wall opposite the door was a hole about one and three-fourths feet in diameter, which was closed by a rubber cap with a central opening, through which the head of the animal was pushed; a rubber cuff was placed around the well-shaven neck in such a way as to avoid all ingress and egress of air. The box was large enough to hold an operating-table on which the trunk of the animal was placed,

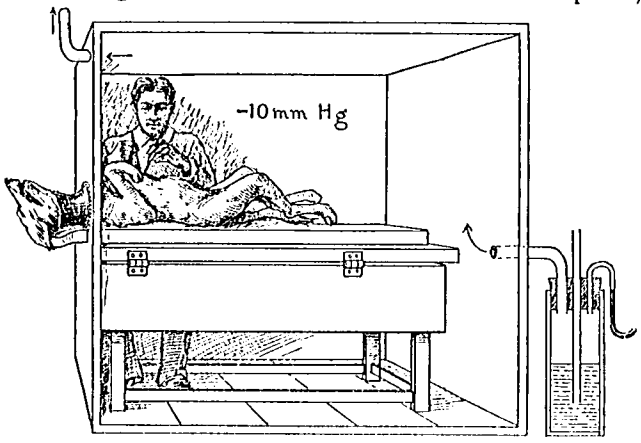

FIG. 2.—Sauerbruch's first wooden box, designed for intrathoracic operative work under negative air-pressure.

and besides furnished seating capacity on either side of the table for operator and assistant. In the upper corner of the wall which had the large opening was a smaller one, about the size of a silver quarter, which was connected with a suction-pump. In the opposite wall was one of the same size, constructed with a valve allowing the access of just sufficient fresh air to produce within the box the desired degree of under-pressure. Once in every four minutes the entire air within the box was changed. Ten millimetres Hg (mercury) proved the amount of negative pressure best adapted for these operations. Two persons could well work in the box for two hours without interruption and without appreciable personal inconvenience. Of course, the temperature within always rose by several degrees, from about 68° to 73° or 74° F., and the

percentage of humidity also increased, drawbacks which were soon overcome, in part at least, by the construction of a larger box for operations on the human subject. Among the operations done in above described box were resections of the œsophagus and of the lungs, opening of the pericardium and mediastinum. The glass top, besides admitting the light, gave a welcome chance to a number of spectators to witness the interesting work done within.

How far intrathoracic operations can be carried out in this way without immediately jeopardizing the life of the animal, is well illustrated by the following operations done on a chloroformized dog:

First, a large, bilateral flap resection of the thorax was done; then œsophagotomy added, and the pericardium with mediastinum opened. After closure of the wounds, the animal came to and was able to run about the room. As the operation had to be done without aseptic precautions and suture of ribs, death ensued on the second day. At the autopsy both lungs collapsed when the pleural cavities were opened, same as we are wont to see happen under normal conditions, and without showing any atelectatic portions.

The cardinal question of the feasibility of such operations under negative pressure having been demonstrated, a larger room, one with fourteen cubic metres of air space as against two in the old box, was built at the Breslau Clinic (Fig. 3). It was arranged for operations under increased as well as negative pressure. It would lead me too far to give a detailed description of it here, but those interested I would refer to Sauerbruch's extensive article in *Mitteilungen aus den Grenzgebieten der Medizin und Chirurgie*, Vol. xiii, Tome 3, entitled, "Zur Pathologie des offenen Pneumothorax und die Grundlage meines Verfahrens zu seiner Ausschaltung."

It was in this larger box that I had the privilege, in July last, to see Dr. Sauerbruch himself, assisted by Dr. Gottstein for many years assistant to the Clinic), do an operation which hitherto had been merely a surgical dream. Five persons were in the room, which was brilliantly illuminated by a large arc-

lamp and a number of smaller electric lights, namely, the operator and his assistant, one person to hand him the instruments, another to communicate with the outside, if required, by means of a telephone, and do such minor detail work as might become necessary during the operation, and myself. The narcotizer, of course, remained outside, but was able, in spite of double windows and the noise produced by the air-pump, to

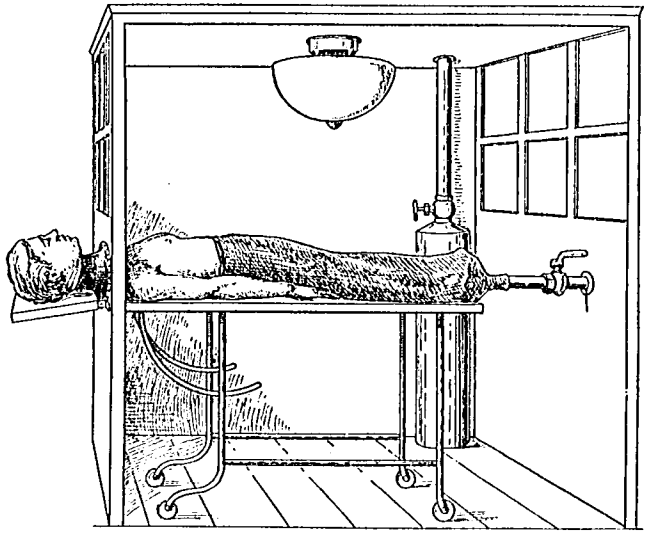

FIG. 3.—The chamber which is used at present for operations under negative air-pressure at the Breslau Clinic.* (A rubber sac, covered by canvas, surrounds the lower half of the patient's body. It connects with the outside by means of a straight tube. Thus the entire body of the patient, with the exception of the thorax and upper extremities, remains under ordinary atmospheric pressure. This arrangement maintains the normal pressure difference between the veins and the right atrium, and prevents stasis of the blood.)

hear the instructions called out by the operator. A number of interested assistants and other physicians stood outside watching the procedure. It was the hottest day of one of the hottest summers experienced in Germany within the last twenty years, and, while perspiration flowed freely, we all felt quite comfortable in this comparatively small room.

* Two more instructive illustrations, showing the details of the interior of the chamber, will be found in Sauerbruch's article.

A fair-sized dog, whose chest had been well shaved, was placed upon a pillow on the operating-table with the left side of his body thus pushed forward. The head and neck of the animal were outside of the box, a rubber cuff being fitted around his neck rather loosely, as it had been found unnecessary, in the course of experiments, to completely shut off the air at this point, the pressure controlling apparatus regulating matters perfectly, even if some air should enter at the head-hole; in fact, what little air could enter in this way had proven useful in helping to ventilate the cabinet. Then the operation was begun under due aseptic precautions. Longitudinal incision, about twelve centimetres long, in the fifth intercostal space, the various tissues being divided parallel to the ribs and the costal pleura cut down upon. No collapse of the lungs; the dog continued to breathe normally. The lung which appeared to be in the way was quickly pushed aside and the œsophagus attacked; it was grasped with the left thumb and forefinger and pulled forward. The nervus vagus on either side was pushed back with forceps; they do not appear again during the operation. The foramen œsophageum of the diaphragm is entered into with the finger and bluntly torn, sufficiently far, to permit of pulling the cardia and adjoining parts of the stomach into the thorax. All this is easily and quickly done under full view of the spectators. Although both pleural cavities had now been opened and were widely gaping, breathing continued undisturbed as before. Aseptic gauze tamponade to all sides. The œsophagus, after being clamped above and below the division line, is cut half-way around only, in order to enable the operator to first catch the mucous membrane with small forceps, as it has a great tendency to retract. After this, total division. Then threefold purse-string suture with silk,* one above the other, the wall of the stomach being deeply grasped; inversion of cardia (supposed to be the seat of carcinoma) into the stomach, in this way shutting it off from circulation. This manœuvre is assisted by two forceps pushing the cardia inward. A few additional interrupted sutures secure the inversion. Thus the portion of the œsophagus near the cardia, being the seat of a carcinoma, is not cut out, but left in place, and shut off from circulation by inversion into the gastric cavity. Such an inverted

* Silk was used throughout the operation.

portion of cardia, as Dr. Sauerbruch told me, had later at the autopsy often been found as a totally necrosed part within the stomach.

Then the posterior wall of the stomach was caught with two forceps, put on the stretch, and stitched to the posterior circumference of the œsophagus with interrupted silk sutures, same as is done in gastro-enterostomy with needle and thread. Thereupon the stomach was opened and united with the œsophagus by interrupted (silk) sutures, embracing the entire thickness of both organs. As much as possible of the anterior aspect is pulled to either side of the sutures in order to leave the smallest possible distance to close at the anterior circumference. Before this latter step had been accomplished, the animal vomited, flooding the operating field with stomach contents mixed with some blood. Fortunately, the greater part of this fluid was caught by the tampons. All having been carefully mopped away, the operation was again proceeded with. A few additional sutures were placed so as to pull the stomach over the œsophagus, and at last two stitches, one on either side, suspend the stomach in such a way that the original anastomosis is literally surrounded by the stomach wall. Finally, the wounds in the diaphragm and the peritoneum were closed around the œsophagus by stitching the same to the latter above the field of anastomosis without perforating the œsophagus, of course. In this way the entire place of anastomosis is buried within the peritoneal cavity. Irrigation with saline solution, generally employed by von Mikulicz at this stage of the operation, was omitted in this instance. Thereupon removal of the tampons and stitching of lower cut surface of the intercostal muscles to that of the upper one, including the superficial thoracic muscles, with interrupted sutures, about one-half inch apart, by which means the superficial muscles were partially inverted. Sufficient space remains between these sutures to see the lung beneath them. Then an increased working of the suction-pump was ordered, to produce greater negative pressure. This expands the lungs so that they lie close to the costal pleura again; now a second continuous muscular suture is put in, which hermetically seals the thoracic cavity. After this, fresh air is allowed to enter the box, and the skin wound is closed by a continuous suture and covered with iodoform collodion. The dog's pulse was good at the completion of the operation.

Through the courtesy of Dr. Sauerbruch I can add the following postoperative history of the dog operated upon: The animal did well during the first days following the operation. On the sixth day, dyspnœa, vomiting, rise of temperature set in, with dulness over the left pleural cavity. Diagnosis: empyema. Reopening of the wound gave exit to a large amount of pus. Drainage. The animal gradually recuperated. Four weeks later some stomach contents escaped out of a channel fourteen centimetres long, which latter, after two weeks, closed spontaneously.

It was evident, Sauerbruch states, that the suture did not close water-tight, a difficulty often met with in this kind of operations. The animal is still alive.

The appearance of an empyema in this case was no surprise to me. The mere fact that the animal vomited just before the completion of the anastomosis, thereby soiling the entire operating field, would seem sufficient to account for it. Besides, the occlusion was not perfect everywhere, a fistula discharging stomach contents became temporarily established.

It is interesting to note that the infection took place along the track of the operation, involving the pleural and not the peritoneal cavity. Of considerable additional interest to me was the following incident that occurred during the operation, which certainly was done with admirable skill and precision.

The supply of a certain size of silk had given out in the midst of the work, and had to be replenished without interfering with the physical conditions of the chamber. Here the wisely arranged anteroom, as shown in the accompanying illustration (Fig. 4), and described in Sauerbruch's exhaustive article referred to above, proved of invaluable utility. The attendant outside of the box was informed of the need, and promptly placed the desired silk into the anteroom, shutting the door, which fits air-tight. Now the suction-pump included the anteroom in its sphere of action, after which the door between this compartment and the main room could be opened with immunity and the required silk obtained.

Surely, the arrangement of the chamber is most ingenious in every detail, being based upon careful experimental research as regards the required physical and physiological conditions.

And, in order that no mechanical accident may interfere with the operation, duplicates of all the parts of the outfit, from the engine down to the electric lights, are kept in readiness for instant substitution.*

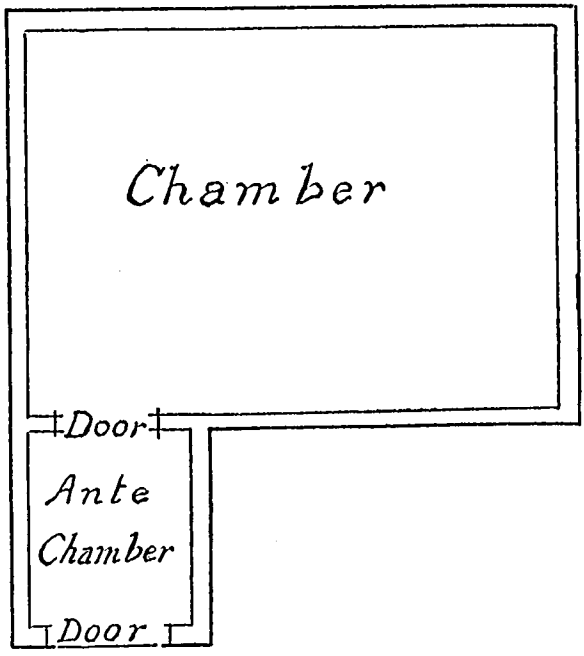

FIG. 4.—Showing the relation of chamber and antechamber. The latter can be put under negative pressure, too, and temporarily used as an additional room, if need be.

In his article "On Operations within the Thoracic Cavity with the Help of Sauerbruch's Box" (*Deutsche med. Wochen-*

* Dr. Wilms, of Leipzig, has shown a way of communicating between those within and those outside of the box without the use of an especially constructed anteroom (*Centralbl. für Chir.*, 1904, No. 8, p. 564). He also suggests a simplification in the construction of the Sauerbruch box, by making use of water to render the box air-tight. He would have the floor of the box separate and arranged with a gutter all around, filled with water, to receive the upper part of the box, the latter to be raised or lowered by pulleys. He further advocates the use of tin for the bottom and transparent celluloid plates for the upper part of the box.

schr., April 14, 1904), Professor von Mikulicz, after referring to some of his experiments done within the same, and expressing his satisfaction at the easy access he has been able to gain to the œsophagus in his intercostal thoracotomies, points out the greater difficulties that exist in connection with œsophageal as compared to intestinal resections.

"The straight muscular tube," he says, "which we call 'œsophagus,' is but little stretchable; hence, even simple division and reuniting of the cut ends is not easily accomplished, as the œsophagus is slightly shortened thereby, and the consequent tension is apt to cause the divided ends to retract. In resections, of course, this difficulty is far greater."

Furthermore, the pleura, in most unwelcome contradistinction to the peritoneum, has little tendency to form rapid adhesions; and, hence, infection is often carried from without inward when draining the pleural cavity, no matter whether gauze, rubber drainage-tubes, or glass drains be used. As a result of such infection, empyema sets in.*

In view of all this, it is plain that the avoidance of a pneumothorax does not eliminate all obstacles in the way of our successfully operating upon the œsophagus.

Von Mikulicz classifies as distinct types resections of the upper and resections of the lower portion of the œsophagus; the latter offering much less difficulty than the former, for the reason that here the cardiac portion as well as the fundus of the stomach can be drawn up sufficiently to make up for the defect caused by the resection. This type of œsophageal resection is best carried out by an anterior intercostal thoracotomy in the fifth or sixth intercostal space.

According to von Mikulicz, the term "Thoracotomy" should comprise all incisions of the thoracic cavity, the same as laparotomy is understood to cover those of the abdomen.

For resections of the upper thoracic portion of the œsophagus, posterior thoracotomy in the third to fifth intercostal space

* For the purpose of reducing or eliminating the danger from infection during the after-treatment, von Mikulicz has constructed a small box, which is placed upon the wound so as to shut it off from all outside air.

has been found to give best results. The tube is here exposed right behind the hilus of the lungs. The vena azygos, which crosses the œsophagus at this place, is either pushed aside or doubly ligated and divided. Although it is feasible to sufficiently stretch the two ends of the resected œsophagus to perform anastomosis, the tension, as indicated above, would be so great as to make it doubtful that the sutures will hold. For this reason von Mikulicz no longer attempts to reunite the divided ends of the œsophagus after high resections, but instead has adopted the following procedure:

The distal end of the œsophagus is closed and dropped back. Then the wound in the thorax is carefully closed by layer sutures, and the proximal stump pulled out of an incision made along the lower end of the anterior border of the sternocleido muscle. This is easily accomplished because of the loose connective tissue around the œsophagus in the median line. The neck wound having been closed by sutures, this upper end of the œsophagus is then drawn underneath a bridge of skin and its end fixed in a small new incision above the second intercostal space, the step being similar to that employed in gastrostomy according to the Ssabanejew-Frank method. It is von Mikulicz's intention later to unite this opening with the gastric fistula by means of a special apparatus, thus making possible a way of feeding by mouth. A gastric fistula has, of course, to be established in all these cases. Unfortunately, the experiments for this purpose cannot be done upon dogs, as they do not stand feeding through a gastric fistula. But the descent of food into the stomach after such a procedure could be accomplished only by massaging the bridge of skin which substitutes the defect in the œsophagus.

No doubt it will be extremely interesting to watch future developments in this direction. Certainly, as von Mikulicz so eloquently points out in closing his article, these are highly interesting surgical problems of the future, in which our imagination is given almost unlimited scope.

To my mind, there does not seem to be any valid reason why the same good result that was obtained in the operation

upon the dog described above, should not be obtained in the human subject; and, if such an operation should prove successful in a case of cancer at or near the cardia, the prognosis would be rather good in view of the slight tendency of œsophageal carcinoma to form metastases.

So far, the few resections of the œsophagus done on the human subject within Sauerbruch's box at the Breslau Clinic (three in number) have resulted in the patients' death.

Since then Sauerbruch has not been idle.* He has perfected the technique in a conclusive way, at least in animals. In the *Centralblatt für Chirurgie*, January 28, 1905, he publishes his present method of operation. It certainly must be gratifying to American surgeons to know that the Murphy button has been the means of making these operations feasible and safe.

Sauerbruch distinguishes two methods:

1. Anastomosis between œsophagus and stomach;
2. Resection of the œsophagus.

These operations, it seems to me, may well be compared with our operations on the stomach done for carcinoma of the pylorus, viz.:

In inextirpable growths: on the stomach, gastro-enterostomy, on the œsophagus, œsophagogastrostomy; in excisable strictures, benign or malignant: on the stomach, resection of pylorus with closure of either end, plus gastro-enterostomy, on the œsophagus, œsophagogastrostomy, resection of the diseased portion and closure of either end.

1. *Anastomosing Œsophagus and Stomach.*—Having exposed the œsophagus as described above, under strictest aseptic precautions, the anatomical relations of the various parts surrounding and covering it are not disturbed in the least. The double serous covering of the cardiac portion of the œsophagus, viz., pleura and peritoneum, are incised at the foramen œsophageum; the abdominal cavity thus having been opened, the stomach is pulled into the thoracic cavity. Now, one-half

* This portion of the article, describing the recent evolution of Sauerbruch's technique, represents a later addition.

of Murphy's button is introduced from without, by the narcotizer, on an œsophageal sound grasped by the operator, his fingers resting on the outside of the tube and pressed against the anterior œsophageal wall; a short incision over the stem makes it appear. No purse-string suture. In cases of stricture of the cardia, the other half of the button is tied in the fundus of the stomach, and union effected by pushing the two halves together. The stomach is, of course, lifted up to the œsophagus. Careful suture with silk of the diaphragm to the portion of the stomach that has been pulled into the pleural cavity. It is of importance to see that no traction is produced on the stomach by the excursions of the diaphragm; if so, a greater portion of the stomach has to be transposed intrapleurally. Then the anastomosis, diaphragmatic sutures, and pleura are touched with Lugol's solution to induce rapid formation of adhesions; irrigation of the pleural cavity with saline solution and closure of the wound.

Thirteen dogs were thus operated upon and all recovered. Three died suddenly later. Autopsy in two of them showed that the stomach, much distended with fluids, had suddenly slipped into the pleura, compressing the heart. Careful suture will guard against this accident.

2. *Resection of the Œsophagus.*—Œsophagogastrostomy by means of the button, as before. Then, the nervi vagi are isolated two centimetres below the perfected anastomosis, the œsophagus compressed with an intestinal clamp and ligated with a strong silk thread; division. The same manœuvre at lower end of portion to be resected. Inversion of the latter into stomach by means of purse-string suture; stitching of stomach against upper stump in order to protect ligature (inversion here impossible). Closure of wound as above described.

Of eleven dogs operated upon in this way, every one recovered.

Besides these two typical operations, Sauerbruch has worked out a third procedure for resection of the cardia and the lowest portion of the œsophagus. He calls it the *inversion method.* It is done in two sittings.

First Step.—Thoracotomy; separation of diaphragm from œsophagus; isolation of nervi vagi, as before; then inversion of the lowest part of the œsophagus into stomach, the latter having been drawn up into the pleural cavity. Circular fixation of stomach to œsophagus by means of silk sutures. By this manœuvre a protrusion is made into the stomach not unlike the portio vaginalis uteri, consisting of the inverted cardia and the lowest end of the œsophagus. Suture of diaphragm to the wall of the displaced stomach, as before.

Second Step.—Fourteen days later: Laparotomy; pulling out of the stomach and opening same. Under guidance of the fore- and middle finger of the left hand introduced into the organ, the inverted portion of the œsophagus is cut off with Cooper's scissors. Hæmorrhage is slight; closure of wound in stomach and abdominal wall.

This operation, too, has proven signally successful in experiments upon animals. For practical purposes, it is, of course, indicated only in cases of small, clearly circumscribed tumors of the cardia, or lowest portion of the œsophagus. Sauerbruch calls it "the ideal procedure for resection of circumscribed, small tumors of the lowest end of the œsophagus or cardia." *

It is of importance to state that Sauerbruch has tried all these methods on the human cadaver, and found the anatomical relations exactly the same, so that he sees no reason why the successes that attended his operations upon the living dog should not be repeated in the human subject. No doubt we shall soon hear from the Breslau Clinic with regard to these operations performed on man.

What has been definitely shown thus far, however, is the great safety with which resections of the thorax can be done in the human subject under negative pressure obtained by means of Sauerbruch's box; and there can be no doubt that numerous other operations in which the pleural cavity is opened

* A fourth operation was devised by Sauerbruch for resection of the portion corresponding to the bifurcation of the trachea and of that above this place. It is also done at two sittings. The defect is closed by plastic operation.

with or without intent, as, for instance, those on the heart, for traumatic rupture of the diaphragm, for attacking a tuberculous affection of the vertebral bodies in Pott's disease, etc., may also be much more safely done within Sauerbruch's box.

The principal point in connection with intrathoracic operations at the present moment seems to be the question as to whether negative or increased air-pressure should be employed.

A few weeks after the publication of Dr. Sauerbruch's article, a short communication by Professor Brauer and Dr. Petersen, both of Heidelberg, appeared in the *Zeitschrift für Physiologische Chemie,* Vol. xli, Tome 4, and was soon followed by a more extensive *résumé* of the subject by the same authors, read at the Surgical Congress in Berlin. In it they pointed out the greater simplicity of the procedure, if done under increased instead of negative air-pressure, the employment of the latter always requiring an especially constructed box. They made the animal inhale oxygen from a tank, to which the vapors of the anæsthetic were added by a special arrangement of the bottles (Fig. 5).*

However, von Mikulicz had already carefully weighed the pro's and con's of the two methods, and Professor Brauer, in a later article (*Centralbl. für Chirurgie* No. 14, Beilage, April 9, 1904) acknowledges the priority of the Breslau Clinic in working out this question in all its various aspects.

Von Mikulicz states (*loc. cit.*) that, if increased pressure were shown to be equally as good as decreased or negative pressure, the technique for the production of the required pressure difference between bronchial tree and pleural surface could probably be greatly simplified. Among the possibilities considered by him are:

1. The use of a sort of a diver's helmet surrounding the neck in an air-tight way, the air entering and leaving the same under increased pressure, the narcotic being mixed with it.

2. A narcotizing mask closing mouth and nose air-tight, such as is used by dentists for nitrous oxide anæsthesia. Here, too, the narcotic would have to be mixed with the air.

* *Mitteilungen aus den Grenzgebieten,* Vol. xiii, Tome 3, page 483.

The danger in connection with these two devices would seem to lie in the possibility of the subject's vomiting.

3. Same as under 2, with the exception that tracheotomy is done, and respiration goes on through a tube fitting air-tight in the trachea.

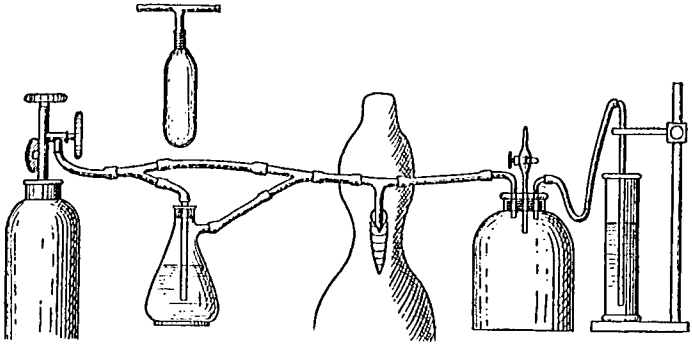

FIG. 5.—Apparatus for the administration of oxygen and chloroform.

Petersen and Brauer have successfully tried this latter method on animals,* employing an accurately working-pump and tank filled with oxygen, with which the narcotic was mixed (Fig. 5).

Sauerbruch's chamber, being arranged for increased as well as negative pressure, could, of course, also well be employed, although it would represent a more costly and complicated device than those above suggested.

Another method, still, has been recently proposed by Dr. F. Kuhn, of Cassel, Germany (*Centralbl. für Chirurgie*, 1904). This author has worked for some years on per-oral and per-nasal intubation, and has now evolved a method of pulmonal anæsthesia produced as follows: Nose and lips are tightly closed; a rubber tube is introduced into the trachea by intubation; at the level of the mouth, this tube passes through a wide

* It has been acknowledged by von Mikulicz that Brauer conceived the idea of using increased pressure for intrathoracic operations independently from and without knowledge of the experiments done at the Breslau Clinic. (*Mitteilungen aus den Grenzgebieten der Medizin und Chirurgie*, Vol. xiii, Tome 3, p. 483, foot-note.)

rubber bandage which surrounds head and neck and, at the same time, holds the tube in position. In this way the lips are closed air-tight, clamps being added for greater safety, if deemed necessary. The nose is closed by compression. Chloroform and oxygen are used. Expiration takes place through Brauer's water-valve under pressure which can be regulated according to the need of the case (Fig. 5). In an article entitled, "No Pressure nor Vomiting during Anæsthesia" (*Berl. klinische Wochenschr.*, 1903, No. 17), he anticipates the objection which, naturally, at once arises in every surgeon's mind,—*i.e.*, what is to be done if the patient should vomit during such an anæsthesia with mouth and nostrils tightly shut,—by declaring that patients thus narcotized do not vomit.*

Personally, I do not think that the method of applying increased air-pressure after tracheotomy will ever find favor in operations on the œsophagus of the human subject, as it complicates matters very considerably. Just imagine a patient of fifty years or older undergoing resection of the œsophagus with a trachea wound and cannula in place. Would not the chances of contracting pneumonia during the after-treatment be greatly increased?

Furthermore, it must be remembered, with all these methods requiring the use of increased pressure, that if anything should happen to any of the apparatuses employed—except when using Sauerbruch's box for the purpose—death would instantly set in, and no amount of duplicate parts could be of any possible use.

This danger is excluded when operating under negative pressure in Sauerbruch's box, since here the defective part could be replaced (duplicates always being kept on hand) without deleterious effect to the subject.

The principle demonstrated by Sauerbruch's discovery is, that rhythmical, artificial charging of the lungs with air, corresponding to normal respiration—as has been long done by

* Since reading this article, another way of narcotizing under increased pressure has been described by Dr. H. G. Engelken, *Deutsche med. Wochenschrift*, 1904, No. 51.

physiologists—is not necessary to continue respiration with the thoracic cavity opened, but that spontaneous respiration goes on regularly and uninterruptedly, if a pressure difference is maintained between the air entering the bronchial tree and that to which the pleural cavity is exposed. This normal respiration goes on uninterruptedly, it may be added, even if the greater part of the thoracic wall is resected.

On the other hand, if the operation in question could be done as well and as safely on the whole, under increased air-pressure, this method would seem to deserve the preference from a clinical as well as financial stand-point. Operations under increased pressure would not have to be done in a closed box, but could be performed before a large audience the same as any other operation, and therefore would not necessitate the construction of a rather costly, special apparatus which here in America would hardly be procurable for less than from $3000 to $4000.

Of course, the great loss of animal heat would have to be considered, if these intrathoracic operations were done in our usual operating rooms.*

In a letter to me of November 3, 1904, Dr. Sauerbruch states that at a recent meeting of physiologists an overwhelming majority declared themselves in favor of negative pressure for intrathoracic operations, on the ground that here the physiological conditions remain undisturbed, while in the increased pressure methods the alveoli of the lungs are necessarily greatly distended. Sauerbruch adds that it will remain to be seen what *surgeons* think about the subject.

I feel sure that American surgeons will take part in this important research work, and do their share in solving the many interesting questions still awaiting decision.

* According to Sauerbruch's experiments, several degrees of heat are rapidly lost if animals (rabbits or dogs) with one thoracic cavity opened are exposed to the ordinary atmospheric temperature. This is due to the great blood-supply of the lungs and the exposure of the heart. With regard to operations, the effects of chloroform or ether—both reducing the bodily temperature—have to be considered as well as the loss of blood. In the box the loss of heat through the opened thoracic cavity is reduced to a minimum.